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RADIO ACCESS NETWORK FOR A MOBILE RADIO COMMUNICATIONS SYSTEM AND OPERATING METHOD THEREFOR

[Funkzugangsnetz für ein Mobilfunk-Kommunikationssystem und Betriebsverfahren dafür]

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Description /1*

The present invention pertains to a radio access network for a mobile radio communications system and to a method for the operation thereof.

Mobile radio communications systems can be divided into a main network, in which user data and signaling data of a number of terminals are transmitted over long distances in a wire-bound fashion, and a radio access network that is also referred to as a RAN (radio access network) and usually comprises a number of nodes that are connected to one or more radio stations and have the function of converting data received from the terminals into a format suitable for transmission on the main network and, vice versa, of adapting the format of data received from the main network to the radio transmission and forwarding these data to the radio station, in the transmitting range of which the relevant terminal is situated.

The transmission of user data and signaling data to the individual terminals, in particular, is a complicated task because the radio station, in the transmitting range of which the relevant terminal is currently situated, needs to be known in the radio access network for each logged-on terminal in order to correctly route data intended for the terminal and because the transmitting range, in which a given terminal is situated, can change at any time due to the mobility of the terminals. Consequently, the access network needs to be able to change the data routing of a terminal at any time during ongoing communication without losing any data.

The data to be routed comprise user data, i.e., data with a relevance defined outside the mobile radio /2
communications system that are input by a user on a transmitting terminal and should be received and output by a receiving terminal as unaltered as possible, as well as signaling data that are generated and processed in order to control internal processes of the mobile radio communications system in

* [Numbers in right margin indicate pagination of the original text.]

connection with the transmission of the user data. Both types of data need to be exchanged between the radio access network and a terminal communicating therewith.

In the access network, one can distinguish between functionalities that are responsible for the transmission of the user data from a node to a terminal and functionalities that are responsible for the transport of signaling data. In this context, the former are referred to as transport functionalities or user plane functions and the latter are referred to as signaling functionalities or control plane functions. The signaling functionalities comprise, e.g., tasks such as the management of radio resources or of wire-bound signaling channels to the main network, mobility management, and forwarding of signaling information that is not specific to the radio access network to the main network.

In the current GSM and UMTS mobile radio communications standards, the signaling functionalities are respectively implemented at the physical nodes of the network that also serve as concentrators for the user data traffic of several transmitting stations. This node is the base station controller (BSC) in the GSM standard and is referred to as the Serving Radio Network Controller (S-RNC) in the UMTS standard. The signaling functionality and the transport functionality for a terminal situated in the transmitting range of a connected base station are respectively assigned to these network nodes. /3
The signaling functionality and the transport functionality for a given terminal are assigned the same physical address because they are always implemented jointly at the same physical node. When an active terminal exits the geographic area covered by one node and enters an area covered by another node in such an access network, it is necessary to shift the transport functionality and the signaling functionality to the new node. This process is associated with a significant signaling effort within the access network that impairs its transport capacity for user data and is time-consuming.

The present invention aims to disclose a radio access network for a mobile radio communications system and an operating method therefor that make it possible to minimize the signaling effort when a

terminal crosses over from the area of an old node into the area of a new node and to thusly realize an efficient operation of the network.

The invention is based on the fundamental idea of separating the transport functionality and the signaling functionality.

The aforementioned objective is attained with a radio access network for a mobile radio communications system with a number of first nodes that are respectively assigned to a subarea of a geographical area covered by the radio access network and serve for exchanging user data between terminals situated in the relevant subarea on one hand and a main network of the mobile radio communications system on the other hand, and with at least one second node featuring a number of functional units that are referred to as signaling functionalities and respectively serve for exchanging /4 signaling data with one terminal and the internal signaling that is dependent thereon, wherein this radio access network is characterized by the fact that the second node is connected to a number of first nodes in order to exchange signaling data with a terminal via the first node, with which this terminal also exchanges user data.

The number of signaling functionalities required for supplying several terminals can be respectively realized at a node with a number of circuits or circuit groups that can be respectively assigned to one terminal in order to fulfill its signaling needs; in an abstract sense, however, they may also consist of portions of the processing power such as, e.g., computing time slices of a physically inseparable processor unit that are assigned to the individual terminals according to requirements.

Due to the inventive ability of the second node to communicate with a number of first nodes, it is no longer necessary to locally shift the signaling functionality assigned to a terminal in the access network when the terminal crosses over into the area of a new first node. In such instances, it suffices to merely shift the transport functionality to the new first node; in order to continue the signaling, it suffices if the

signaling functionality is provided with information on the new first node, to which the signaling data need to be transmitted after the crossover in order to reach the terminal.

The user data transport is preferably organized analogous to the signaling in such a way that the first nodes respectively feature a number of transport functionalities that can be respectively assigned to one terminal and exchange user data with the terminal. Since this transport functionality and the signaling functionality are respectively assigned to a terminal individually when communication is established, it is preferred that the respective functionalities have different addresses that can be used for respectively exchanging user data and signaling data in the access network.

According to a first simple embodiment of the inventive radio access network, only one second node is provided and connected to each first node. Consequently, the signaling functionalities for the entire access network are centralized at the one second node.

According to a preferred second embodiment, the radio access network comprises a number of second nodes and each second node respectively communicates with at least one first node that is referred to as its core node, as well as with all other first nodes of the access network, the subareas of which border on that of the core node. When a terminal that is situated in the subarea assigned to such a core node establishes communication and is assigned a signaling functionality at a second node, it can move within the subareas of all core nodes and of the nodes bordering thereon without having to shift the signaling functionality. If one envisions, e.g., that such a subarea respectively corresponds to an MSC region in a GSM radio communications system, it becomes clear that only a very few communications are successively routed in more than two MSC regions. Consequently, it will usually suffice if exactly one core node is assigned to each second node in order to be able to finish communications that have started in the area of this core node without shifting the signaling functionality.

Although the total number of connections required for transmitting signaling data between the first /6 and second nodes is higher in this second embodiment than in the first embodiment, the expenditures required for correctly forwarding the signaling data are lower due to the smaller number of respectively connected first nodes and the connections remain shorter than in the first embodiment.

Each first node preferably forms the core node of at least one second node. Due to this measure, any communication that was started in the radio communications system can be continued without shifting the signaling functionality, namely even if the terminal participating in the communication moves from the area of the node in which the communication was started into the area of a bordering node.

Other characteristics and advantages of the invention are discussed in the following description of embodiments that refers to the enclosed drawings.

In these drawings:

Figure 1 shows a block diagram of an inventive radio access network between a main network and a number of terminals, and

Figure 2 shows a block diagram of a second inventive access network.

The access network RAN shown in Figure 1 comprises a number of first nodes that are also referred to as User Plane Servers, UPS, wherein only the two first nodes UPS1 and UPS2 are illustrated in the figure. Each of these first nodes UPS1, UPS2 is connected to a number of base stations (that are not /7 illustrated in the figure) and communicates by radio with a number of terminals UE via these base stations. In the access network RAN, the user data traffic that is illustrated in the form of thick continuous lines in the figure takes place between the first nodes and the main network CN on one hand and the terminals UE on the other hand.

Each first node has a number of transport functionalities UPF (User Plane Functions) that are respectively assigned an address within the access network RAN, wherein this address serves for routing

data packets intended for a certain terminal UE to the transport functionality UPF that communicates with this terminal UE.

The access network RAN furthermore features a second type of nodes that are identified by the reference symbols RCS1, RCS2 (Radio Control Server) in the figure and are responsible for the exchange of signaling data within the access network and between the terminals UE and the main network CN. The second node RCS1 features a plurality of functional units that are referred to as signaling functionalities UEF (User Equipment Function), wherein these signaling functionalities are responsible for the tasks associated with the signaling of the assigned terminal and each signaling functionality is assigned to exactly one active terminal. In this case, the signaling functionalities UEF are implemented in the form of abstract portions of the processing power of the second node RCS1; they respectively exist only as long as the terminal assigned thereto communicates with the access network RAN. Separate addresses are respectively assigned to the signaling functionalities in order to transport signaling data relevant to the respectively assigned terminal within the access network.

The second node RCS2 contains a management unit UAF (User Allocation Function) that is notified /8
by a first node such as, e.g., the node UPS1 as soon as a terminal UE attempts to establish communication with the relevant node UPS1. The management unit UAF subsequently assigns a signaling functionality UEF to the terminal UE at the second node RCS1 and transmits the address thereof to the first node UPS1 such that it can correctly address signaling information concerning the terminal to the assigned signaling functionality UEF.

As long as the observed terminal UE is situated in the area of the first node UPS1, user data that arrive from the main network CN and that are intended for this terminal are directly routed to the terminal UE via the first node UPS1. Signaling data arriving from the main network CN, in contrast,

initially pass through the second node RCS1, from where they are forwarded to the correct first node by the assigned signaling functionality.

When the terminal UE exits the geographical area covered by the first node UPS1 and enters that of the node UPS2, the corresponding transport functionality UPF is suspended at the node UPS1 and is established anew at the node UPS2. The exchange of signaling data required for this purpose is carried out by the corresponding signaling functionality UEF of the second node RCS1; however, the signaling functionality UEF itself remains at its node RCS1. During the change of the terminal to the node UPS2, it is therefore only necessary to forward the parameters of the communication established by the terminal that are required for the user data traffic to the node UPS2, but not the parameters that are relevant to signaling only. The quantity of signaling data to be exchanged within the access network RAN in connection with the movement of the terminal UE consequently is smaller than in conventional /9
instances, in which the transport functionality and the signaling functionality need to be shifted, wherein the adaptation process can also be carried out faster and the transport capacity of the access to the network is only slightly affected by the adaptation process.

The signaling functionalities UEF and the management unit UAF that are realized at different second nodes RCS1, RCS2 in the embodiment according to Figure 1 naturally may also be combined at a single node.

It would also be conceivable for the access network to only feature a single management unit UAF, but a number of second nodes with signaling functionalities. This configuration is illustrated in Figure 2. In this figure, the entirety of hexagonal fields A, a symbolizes the geographical area over which the access network RAN extends. Each individual hexagon A, a corresponds to the subarea that is covered by the base stations connected to a given first node. The first nodes UPS1, UPS2 ... assigned to each of these subareas are respectively illustrated in the form of boxes within a hexagonal field A, a. Second

nodes RCS1, RCS2 … are respectively connected to a number of first nodes UPS1, UPS2 … in order to exchange signaling information, wherein all of these connections are, however, only illustrated in the form of continuous or broken lines for the second node RCS1. A continuous connection extends from the second node RCS1 to the first node UPS1. In this case, the node UPS1 is referred to as the core node of the second node RCS1 because the subarea A supplied by this node effectively forms the core of the region supplied by the second node RCS1; it is completely surrounded by subareas a, the first nodes of which are also connected to the second node RCS1, namely via the connections illustrated with broken lines.

When a terminal establishes communication in the subarea A of the first node UPS1, a signaling functionality, if available, is assigned to the terminal at the second node RCS1 by the management unit UAF. It can then move from the subarea A into all surrounding subareas a without having to shift its signaling functionality from the second node RCS1 to another second node.

In order to realize this advantage in all subareas A, a of the access network, each first node UPS1, UPS2 … forms the core node of at least one second node RCS1, RCS2 ….

Consequently, each first node is practically connected to a number of second nodes: the connection to the second node, for which it forms the core node, is illustrated with a continuous line and the connection to a second node, for which it forms part of the boundary area of the supplied region, is illustrated with a broken line. This assignment of a first node to several second nodes is illustrated in the figure, e.g., in the form of the first node UPS2 that is connected to the second nodes RCS1 and RCS2 and provides the additional advantage of an increased flexibility in the assignment of the signaling functionalities to a terminal UE: if a terminal UE attempts to establish a connection in the area of the first node UPS2 and no signaling functionality is available at the second node RCS2, a signaling functionality can be assigned to the terminal UE at the node RCS1.

In a first variation of this embodiment, each first node is assigned to exactly one second node as core node; i.e., there are exactly as many first nodes UPS as second nodes RCS. In this variation, it is /11 naturally practical to arrange a first node and the second node, for which the former forms the core node, together in one structural unit. However, one significant difference in comparison with known access networks, in which signaling functionalities and user data transport functionalities are also realized in one structural unit, can be seen in that the second nodes of the disclosed access network can also directly exchange signaling data with the first nodes of bordering subareas, and in that the different addresses of the signaling functionality and the transport functionality make it possible to address both functionalities independently of one another as already mentioned above with reference to Figure 1.

This first variation is characterized in that all connections between the first and second nodes are no longer than the dimension of a subarea A, a, wherein significantly longer connections may be required in the instance illustrated in Figure 1, in which signaling functions UEF are only available at a single second node; however, the number of required connections is very high. In order to reduce this number, it is therefore practical if each first node UPS1, UPS2, ... is assigned to exactly one second node as core node, but the second nodes respectively have a number of first nodes as core nodes as illustrated, for example, for the second node RCS4 in Figure 2.

<u>Claims</u> /12

1. A radio access network (RAN) for a mobile radio communications system with a number of first nodes (UPS1, UPS2, ...) that are respectively assigned to a subarea (A, a) of a geographical area covered by the radio access network (RAN) and serve for exchanging user data between terminals (UE) situated in the relevant subarea and a main network (CN), and with at least one second node (RCS1, RCS2) featuring a number of functional units that are referred to as signaling functionalities (UEF) and

respectively serve for exchanging signaling data with one terminal (UE), characterized by the fact that the second node (RCS1, RCS2,...) is connected to a number of first nodes (UPS1, UPS2, ...) in order to exchange signaling data with a terminal (UE) via the first node (UPS1, UPS2, ...), with which this terminal (UE) exchanges user data.

2. The radio access network according to Claim 1, characterized by a management unit (UAF) for assigning a signaling functionality (UEF) to a terminal (UE) when communication is established by means of the terminal (UE).

3. The radio access network according to one of the preceding claims, characterized by the fact that the first nodes (UPS1, UPS2, ...) respectively feature a number of transport functionalities (UPF) that can be respectively assigned to one terminal (UE) and exchange user data with the terminal (UE), and by the fact that the addresses assigned to the signaling functionalities (UEF) and the transport functionalities (UPF) for the purpose of exchanging user data and signaling data respectively differ for functionalities assigned to the same terminal (UE).

4. The radio access network according to one of the preceding claims, characterized by the fact that it /13
features only one second node (RCS1) that is connected to each first node (UPS1, UPS2).

5. The radio access network according to one of Claims 1-3, characterized by the fact that it comprises a number of second nodes (RCS1, RCS2, RCS3, RCS4), and by the fact that each second node is respectively connected to one first node (UPS1) that is referred to as its core node, as well as to all first nodes, the subareas (a) of which border on the subarea (A) of the core node.

6. The radio access network according to Claim 4, characterized by the fact that each first node forms the core node of at least one second node.

7. A method for operating a radio access network for a mobile radio communications system with a number of first nodes (UPS1, UPS2, ...) that are respectively assigned to a subarea (A, a) of a

geographical area covered by the radio access network (RAN) and respectively feature a number of functional units that are referred to as transport functionalities (UPF), wherein these transport functionalities can be respectively assigned to one terminal (UE) situated in the relevant subarea (A) and are designed for respectively exchanging user data with the terminal (UE), and with at least one second node (RCS1, RCS2 …) featuring a number of functional units that are referred to as signaling functionalities (UEF) and respectively serve for exchanging signaling data with one terminal (UE), wherein a transport functionality (UPF) and a signaling functionality (UEF) are assigned to a terminal (UE) when communication with the radio access network (RAN) is established, characterized by the fact that the signaling functionality (UEF) transmits signaling data to the terminal (UE) via the assigned first /14
node (UPS1), and by the fact that, when the terminal crosses over from one subarea into another subarea that is assigned to a new first node (UPS2), a new transport functionality (UPF) is assigned to the terminal (UE) at the new first node (UPS2) and the signaling functionality (UEF) transmits signaling data to the terminal (UE) via the new first node (UPS2).

8. The method according to Claim 7, characterized by the fact that the transport and signaling functionalities assigned to a given terminal have different addresses, and that user data and signaling data intended for the terminal are transported in the access network (RAN) with the aid of these different addresses.

9. The method according to Claim 8, characterized by the fact that the signaling functionality is informed of a crossover of the terminal (UE) into a new subarea, and by the fact that the signaling functionality (UEF) subsequently transmits signaling data intended for the terminal (UE) to the new first node (UPS2).

10. The method according to one of Claims 7-9, characterized by the fact that, if the access network (RAN) comprises a number of second nodes (RCS1, RCS2, RCS3, RCS4) and each second node (RCS1,

RCS2, RCS3, RCS4) is respectively connected to one first node (UPS1, UPS2, UPS3, UPS4) that is referred to as its core node, as well as to all first nodes, the subareas (a) of which border on the subarea (A) of the core node, the signaling functionality is assigned to the terminal (UE) at a second node (RCS1), for which the first node (UPS1) of the subarea (A), in which the terminal is situated, forms the core node when communication is established.

Fig. 1

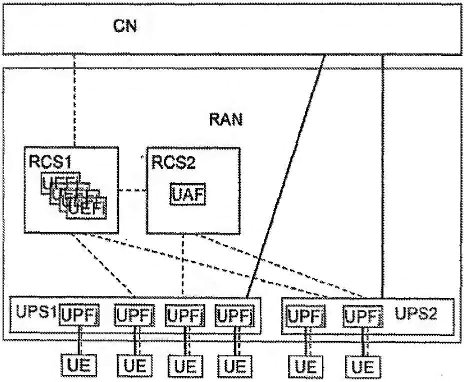

Fig. 2